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AN OPERATIONAL TEST OF A TRADEOFF EVALUATION PROCEDURE IN FOREST SERVICE PLANNING

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Final Report

AN OPERATIONAL TEST OF A

TRADEOFF EVALUATION PROCEDURE

IN FOREST SERVICE PLANNING

by

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for

The Rocky Mountain Forest and Range Experiment Station

and

The Intermountain Region

of

The U.S. Forest Service

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ABSTRACT

The development of a decision aid technique for use in land management decision making is presented. An application of the technique on the land management plan of the Uinta National Forest is documented, and recommendations for further refinement of the technique are provided.

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1.0 INTRODUCTION

1.1 BACKGROUND

Public land management decision making typically involves a formal development and analysis of several alternatives prior to selection of a preferred alternative or course of action. Furthermore, Forest Service decision making at other levels (from strategic planning at the national level to action management at the local level) is usually a matter of deciding among explicit alternatives. Though consideration of multiple alternatives in public resources decision making is a standard procedure, decision aid techniques are not in widespread use which systematically organize information about alternatives in a manner that facilitates and documents the decision making process. Moreover, many techniques which are currently in use mask the real differences between alternatives and do not adequately display decision maker value judgements.

A set of decision aid techniques which fall under the general rubric of "factor profiles" has been proposed for addressing some of the information organization and display problems associated with natural resources decision making. This project was intended to explore some of these techniques, to design a

method for applying them in Forest Service land management planning, and to obtain an operational test of the techniques in a real Forest Service planning problem.

1.2 INFORMATION PROBLEMS IN NATURAL RESOURCES PLANNING

1.2.1 Information Requirements

In recent years, federal legislation and agency policy have greatly expanded the responsibilities of natural resources planners and decision makers for producing and managing information for planning. At the federal level, planners and decision makers are now required to address a wide variety of non-commensurate objectives in the formulation and evaluation of resources development alternatives and in the selection of a preferred alternative. In addition, resource management agencies have evolved more thorough and well-defined procedures regarding the kinds of information which must be generated in the formulation, evaluation, and selection of alternatives. As a result, the natural resources planner is faced with a number of information management problems, the solutions to which will require the use of new information management and display techniques.

1.2.2 Types of Information

To evaluate resources development alternatives and to select a preferred alternative from a set of alternatives, two fundamentally different kinds of information must be made available to the planning and decision making process (see Bishop et al., 1976). These are (1) objective, technical information describing the set of feasible, non-inferior alternatives, and (2) subjective, preference information to be used to evaluate trade-offs among alternatives and to select a preferred alternative. In many cases, the large amounts of objective and subjective information which must be generated and displayed can be overwhelming. The net result is that decision makers and interested publics experience an information overload. When deluged with technical and opinion data, decision makers and publics may be worse off than if they had less information for purposes of decision making (McKee, 1979).

1.2.3 Information Loss

A variety of decision aids and planning techniques have been proposed to deal with the information overload problem noted above. Among these are indexing and aggregation methods that collapse complex data sets into less complex sets. These are the so-called "weight-rate-and-calculate" methods. Examples of these include the matrix and linear scoring approaches of Crawford et al. (1973), the Corps of Engineers (1972), Dee et

al. (1972), Leopold et al. (1971), and many techniques currently in use in the U.S. Forest Service (c.f., the Keopner-Trego method, the Alternative Actions Evaluation method, and DECIDE) and other resources planning agencies. Other methologies, such as the Techcom methodology proposed by the Technical Committee of the Water Resources Research Centers of the Thirteen Western States (1974), have more complex indexing and aggregation schemes (see Gum, 1974; McKee, 1974), but in general, the procedures followed by all of these methods require prior assessment of weights and, through a variety of indexing and aggregation processes, reduce the resources planning problem from one of multiple objectives to a single-valued one. These aggregative procedures do not clarify explicit trade-offs, but result in the loss of planning information rather than the management of it (Bishop et al., 1976). Many authors contend that techniques which require prior assessment of weights produce incorrect decisions.

Two major causes of information loss are the structure of the resources planning organization and the structure of the decision making process (McKee and Crawford, 1977; McKee, 1979). The planning and decision making organization is stratified, fragmented, and pyramidal in nature. Forming the base of the pyramid is the lowest stratum consisting of field level planners and technicians. At the apex of the pyramid in the top stratum is the U.S. Congress which appropriates funds for resources development projects. Several layers of planners, decision mak-

ers, and agencies exist between these two strata. Two types of decisions are made at the various strata of the pyramid that contribute to loss of information. One is associated with the upward passage of information from stratum to stratum, and the other deals with how major natural resources development decisions are made and documented.

The former type of decision can affect the upward passage of information and can lead to a type of information loss called "small decision anarchy" by McKee (1979). At each stratum of the resources planning and decision pyramid, decisions are made with regard to what information about various development projects should be passed to the next highest stratum, and what information should not. This in effect creates a filtering mechanism wherein information is gradually lost as one goes higher up the pyramid.

The second type of information loss, called "big decision tyranny" by McKee (1979), is the result of a gap between the gathering and assimilation of technical and public opinion data about the various development alternatives on the one hand, and the actual selection of a preferred alternative on the other. The factors and decision criteria that are finally considered in decision making and the importance that is attached to the various trade-offs between alternatives are usually not clearly disclosed by decision makers. This creates a "grand canyon" gap that one must leap to get from the technical description of al-

ternatives to the final decision itself. Since reasons and rationale are seldom provided, it is often difficult to see how the gap was originally crossed by the decision maker.

1.3 PURPOSE OF THE PROJECT

Simply-stated, the purpose of the project has been to (1) construct a decision aid for use in resources development decision making which neither suffers from the information management problems nor contributes to the information loss problems of techniques currently in use, and (2) test the technique, insofar as possible, in an actual natural resources planning situation. The following chapters present a description of the planning and decision aid that was developed, an example of how the technique was applied on the Uinta National Forest in the selection of a preferred land management plan, a set of conclusions about how well the method has worked on the applications it has received, and a set of speculations about how the method might be improved for future use.

2.0 AN OVERVIEW OF THE TRADE-OFF EVALUATION PROCEDURE

2.1 BASIC ASSUMPTIONS AND PHILOSOPHY

The methodology developed by the project for use in planning and decision making is called the "Trade-off Evaluation Procedure" (TEP). It is based on the earlier approaches of Bishop (1969, 1972) to multiple objective planning problems. Three fundamental assumptions must be accepted in order for TEP to be an attractive decision aid in natural resources management problems:

1. Significant decisions regarding the development, management, and use of public resources should be made on the basis of the importance of the differences and trade-offs among alternatives; techniques which mask differences and trade-offs result in the loss of important information and should be avoided.

2. The rationale for significant decisions affecting public resources should be documented and explicitly displayed.

3. All decisions are subjective or value-laden; resources decision makers make decisions in light of their own sets of values, opinions, and preferences; this means that decision aids should explicitly and systematically incorporate the values and viewpoints of the people using them.

At the heart of TEP, then, is the philosophy that (1) decisions about public resources should be based on the viewpoints that decision makers have about trade-offs between alternatives, and (2) these viewpoints should be made known.

2.2 TERMINOLOGY: "FACTORS"

As is the case with most new technologies, TEP uses a certain vocabulary to describe its parts and their functioning. To understand how TEP works, it is first necessary to understand a few basic terms. These center around the notion of a "factor," and are discussed in the following sections.

A factor is an important output, impact, or effect of an alternative which could be used in comparing alternatives and in expressing differences and trade-offs between alternatives. Factors can be economic, social, or environmental in nature. In wildlands planning, examples of common factors might be timber volume harvested, amounts of grazing made available, amount of wilderness and roadless area provided, number of new jobs provided for a region, etc. In general, the factors that are used in applying TEP to a resources management problem are selected with reference to the public issues and management concerns surrounding that problem. Three kinds of factors can be defined: money-valued, quantity-valued, and non-quantity-valued.

2.2.1 Money-Valued Factors

Money-valued factors are factors for which a monetary price per unit can be readily established in the market place. Examples of money-valued factors would be the change in gross regional product that would result from the implementation of an

alternative, the cost to the taxpayer of implementing a given alternative, or the present net worth of a wildlands resource as the result of a management alternative. It should be emphasized, however, that being priced in the market does not necessarily make a factor money-valued. Artificial constraints on the market or poor management of common-property resources may cause the market price of an item not to reflect the true worth of the item. An example of this would be the price of oil previous to the Arab oil embargo of the 1970's. Consequently, as a general rule, one should not be too quick to describe factors in dollar terms if, for purposes of the decision at hand, the monetary units used do not accurately reflect the worth of the factors.

2.2.2 Quantity- and Non-Quantity-Valued Factors

Factors whose true worth are not readily reflected in the market place may be either quantity-valued or non-quantity-valued. Quantity-valued factors are those which are measurable through some professionally accepted procedure and which pass the test of indifference. By the test of indifference, a factor is quantity-valued if, when given equal amounts of the factor in two different alternatives, one would be indifferent between the alternatives, other things remaining equal. For example, two different alternatives might each provide 100,000 acres of roadless area. In this case, the factor "amount of roadless area" is quantity-valued if one is indiffer-

ent (at least for purposes of the decision at hand) between the 100,000 acres in the first alternative and the 100,000 acres in the second. That is, the factor would be quantity-valued if no qualitative differences existed between equal quantities of the factor. If the roadless areas are on the same land for both alternatives, or if the planner believes that the proposed roadless areas are very similar for both areas, then the factor "amount of roadless area" would probably be judged to be quantity-valued. However, if the roadless area for the first alternative consisted of mountainous land with heavy timber, and the roadless area for the second alternative were located in sagebrush flats, then the factor "amount of roadless area" might be judged to be non-quantity-valued. In other words, even though the amount of roadless area is measurable for both alternatives, if qualitative differences exist between the quantities measured, these quantities are not directly comparable and the factor would be a non-quantity-valued factor.

In general, TEP recognizes a hierarchy among these factor types wherein it is desirable to make as many factors as possible into money-valued factors, and as many of the remaining factors as possible into quantity-valued factors. Non-quantity-valued factors are not less desirable than quantity-valued factors, but they are more difficult to work with in the analysis and evaluation of alternatives. However, it should be stressed that factors should not be judged to be money-valued or quantity-valued if, for purposes of the re-

sources management decision at hand, it makes no sense to do so.

2.3 TEP IN "THE" PLANNING PROCESS

2.3.1 Elements of the National Forest Planning Process

There is no general agreement in the planning community as to what constitutes "the" planning process: there is no unique or best process. However, over the history of federal management of public natural resources, several agencies have evolved which conduct planning activities with reference to specific guidelines and procedures. In response to the National Forest Management Act of 1976 (U.S. Department of Agriculture, 1978), regulations to guide land and resources management planning in the national forest system have been adopted. These regulations list several steps in the planning process, including:

1. Identification of issues, concerns, and opportunities;
2. Development of planning criteria;
3. Collection and inventory of data and information;
4. Analysis of the management situation;
5. Formulation of alternatives;
6. Estimation of effects of alternatives;
7. Evaluation of alternatives; and
8. Selection of a preferred alternative.

While it is unclear in the regulations whether the Forest Service views these activities as occuring in a well-defined, step-by-step, sequential fashion, or more realistically in an iterative, simultaneous-dynamic manner (see Bishop et al., 1976; Ortolano, 1974), the ultimate goal of the planning process is to determine the relative social desirability of proposed resources development alternatives. The process must therefore result in the provision of a basis for determining how proposed actions might impact the interests of individuals and groups, and a means for comparative assessment among alternatives. Its chief purpose is to serve as a viewpoint integrating and decision making activity to produce the design of a preferred course of action.

2.3.2 TEP in the National Forest Planning Process

As will be seen in the sections that follow, the reason TEP was developed was to facilitate steps 7 and 8 above, evaluating alternatives and selecting a preferred alternative. However, practice has shown that trial applications of TEP have been instrumental in spotting weaknesses and oversights in the preceeding steps (such as the formulation of alternatives), and in revising earlier work (e.g., in refining the definition of issues, in re-designing or re-formulating alternatives, or in "fine-tuning" the preferred alternative). Examples of how TEP has been used in these earlier steps of the National Forest planning process will be given in the following chapter.

2.4 MECHANICS OF TEP

2.4.1 Introduction

Most of the work conducted during the course of the project was directed toward the design of TEP. In fact, several versions of TEP have been produced (see Suhr, 1981). The version documented in this report is, in the opinion of the authors, the simplest and most dependable for use by the planning and decision making team. Other versions of TEP have been developed for use with members of the public, but these have not been sufficiently tested.

TEP combines information about the various factors (as these factors describe the management alternatives being considered) with preference and opinion data to arrive at a preferred alternative. In doing this, TEP uses explicit value judgments on the part of decision makers or public interest groups to document the comparison/evaluation process.

The major steps in using the technique are: (1) the organization of data about the various alternatives and factors, (2) comparison of the alternatives and documentation of these comparisons, and (3) summarization of the comparisons in the form of a variety of displays.

In the example that follows (this example has been adapted from one proposed in the RPA planning methodologies report developed by the Rocky Mountain Forest and Range Experiment Station, and previously used by McKee and Simmons, 1978), a hypothetical forest plan is being developed to address problems and concerns that have surfaced regarding dispersed recreation, wilderness, water yield, employment, wildlife habitat, and aesthetics. Four alternatives have been proposed by the planning staff:

1. Alternative A: This alternative is essentially a continuation of past management, with particular emphasis on maintaining past output levels of timber, forage, water, and recreation opportunities;

2. Alternative B: This alternative has a timber products theme, but includes consideration for other resources as well, especially range and recreation;

3. Alternative C: This alternative has a preservation and recreation theme, but allows for timber harvest, livestock grazing, and other commodity outputs; and

4. Alternative D: This alternative has a water and forage theme, but allows for timber harvest, some recreation, and other outputs.

These alternatives can be characterized in terms of their output levels for the following factors:

1. Net benefit ($);

2. Hiking and backpacking trails (miles);

3. Wilderness acreage (1000's of acres (MAC));

4. Employment affected (annual full-time equivalents);

5. Water yield (1000's of acre-feet (MAF));

6. Albert squirrel habitat (wildlife habitat index, 10-point scale); and

7. Scenic beauty, close-up vantage (scenic beauty index, 10-point scale).

Note that the planners have judged factor 1, "net benefit," to be a money-valued factor, while all others are quantity-valued.

2.4.2 Data Organization

2.4.2.1 Summary Table

The first step in the process is the organization of the data. For quantity-valued factors, a tabular summary of the output levels of all factors for all alternatives is useful. Such a summary is presented in Table 2.1.

2.4.2.2 Comparative Descriptions

Though not used in this example, non-quantity-valued factors are used in the decision making process and a simple technique, called comparative descriptions, has been proposed to deal with this kind of factor. This technique utilizes a tabular display format in which:

1. Each non-quantity-valued factor is precisely and thoroughly described for each alternative;
2. If the factor is the same for two or more alternatives, the description is written only once, if possible, so the reader can see instantly that the alternatives are alike. If the description must be

Table 2.1. Description of the Alternatives

Alternatives	Factors						
	1. Net Benefit ($M)	2. Hiking/ Backpacking Trails (miles)	3. Wilderness Acreage (MAC)	4. Employment Affected (annual full time equiv)	5. Water Yield (MAF)	6. Albert Squirrel Habitat (10-point scale)	7. Scenic Beauty Close-up Vantage (10-point scale)
A.	0	55	38.5	589	48.0	7	8
B.	463	42	38.5	706	48.5	5	6
C.	-300	135	83.0	576	48.0	7	8
D.	950	42	38.5	798	49.0	2	4

written twice, exactly the same words are used, or it is indicated that, for example, Alternative C is the "same as A" for that factor; and

3. The comparative descriptions for the alternatives are arranged in close proximity to each other so that it is visually easy to make comparisons between alternatives.

In this manner, all relevant information about the non-quantity-valued factors gets into the planning process.

2.4.2.3 Factor Profiles

A useful display mechanism for discovering dominant or dominated alternatives, or for identifying alternatives that are so similar to one another that they are really the same alternative, is the factor profile. Factor profiles are also invaluable in conducting subsequent portions of TEP. A factor profile is drawn for each alternative by (1) arraying a set of scales, one scale for each quantity-valued factor, on a single piece of paper, (2) plotting each factor value on its appropriate scale, and (3) connecting the plotted points with a broken line. Figures 2.1a through 2.1d illustrate factor profiles for the four example alternatives discussed above.

Dominant or dominated alternatives can be identified by overlaying all profiles on top of one another. A dominant alternative will be better than at least one other alternative for all factors. Similarly, a dominated alternative will be worse than at least one other alternative for all factors.

Figure 2.1a. Factor Profile for Alternative A.

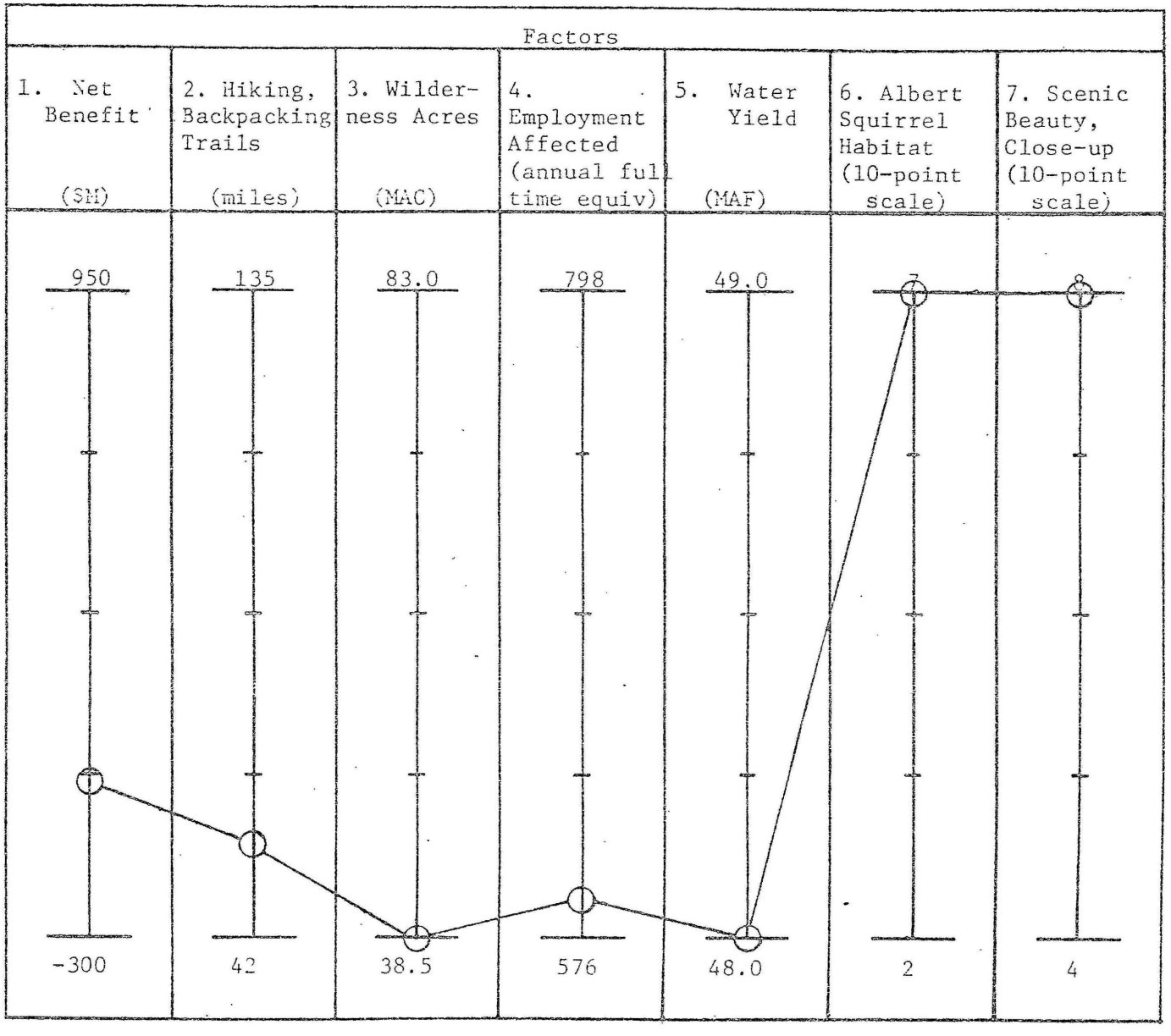


Figure 2.1b. Factor Profile for Alternative B.

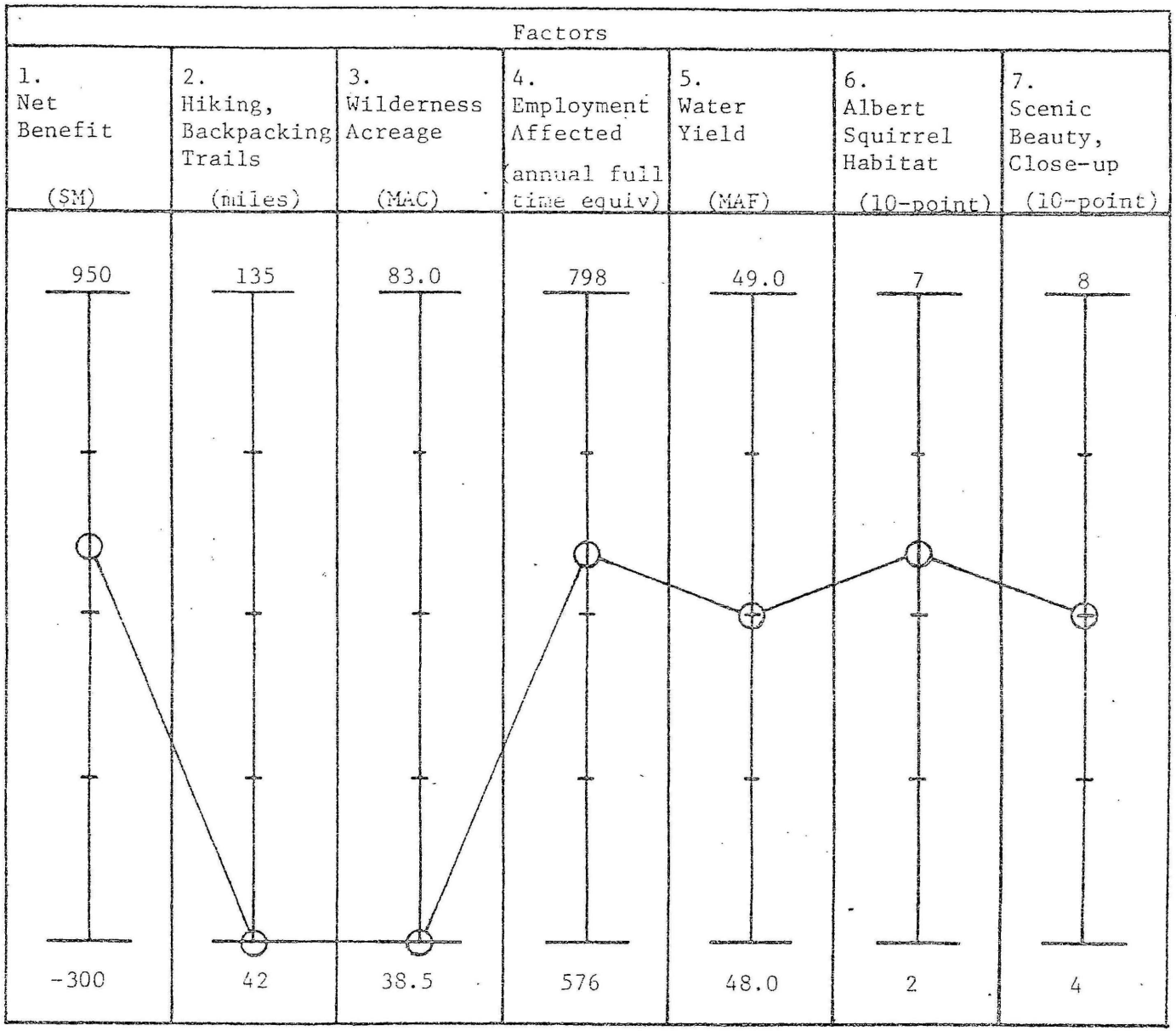


Figure 2.1c. Factor Profile for Alternative C.

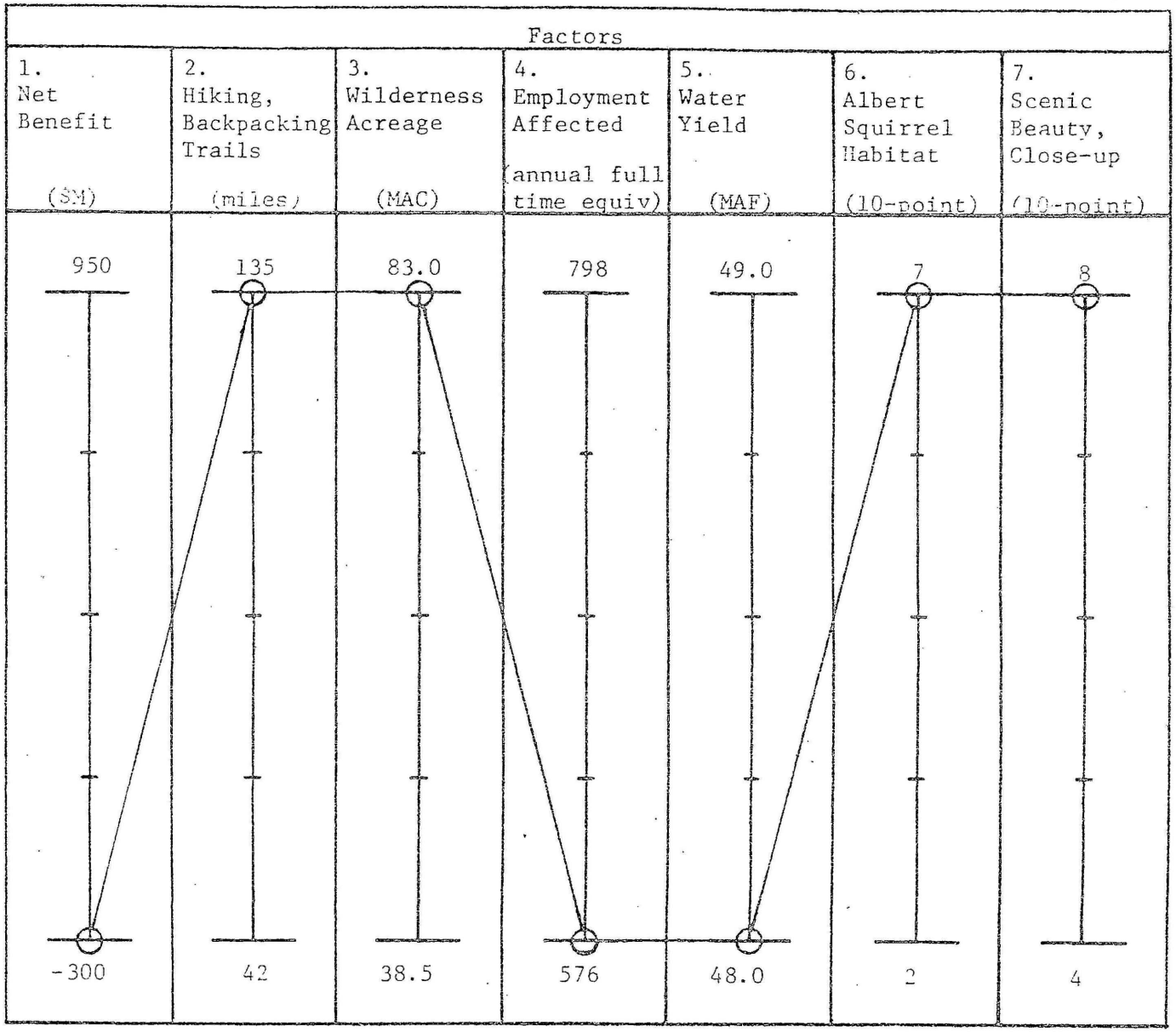
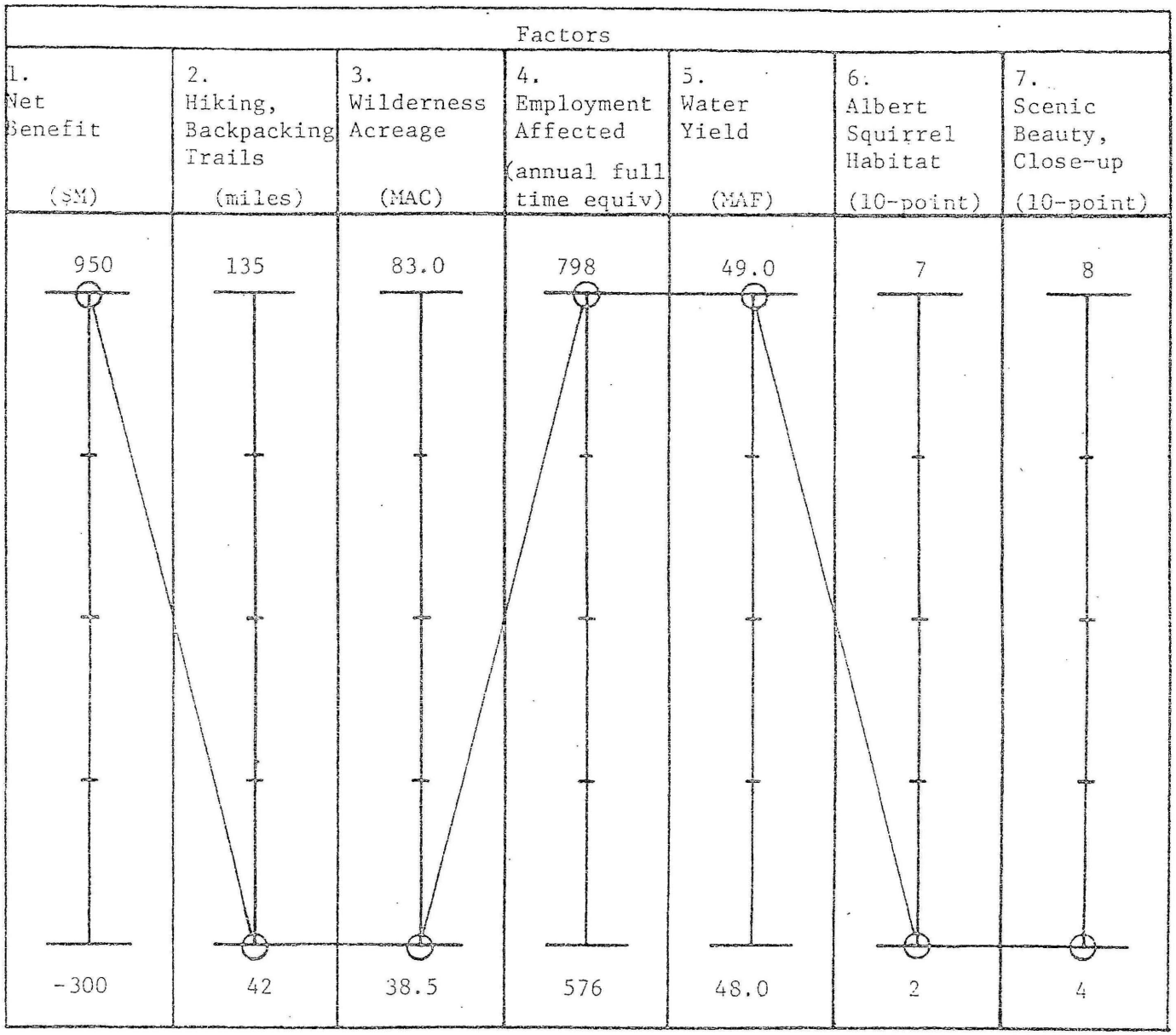


Figure 2.1d. Factor Profile for Alternative D.



Non-alternatives, or alternatives that are essentially the same as each other, will have factor profiles that fall on top of one another.

2.4.3 Comparison of the Alternatives

Five steps are followed in comparing alternatives using this version of TEP:

1. Two alternatives are selected to compare and, using their factor profiles, the display of Figure 2.2 is completed by indicating the differences in the factors for the two alternatives;

2. The differences in the factors between the two alternatives are examined and the decision maker then determines which difference (not which factor) is the most important in comparing the alternatives and deciding which alternative he most prefers;

3. The factor difference judged most important in the previous step is placed at the "100" position on the scale as illustrated in Figure 2.3. In the column labled "FACTOR DIFFERENCES," it is indicated which factor difference this is. In the column entitled "EXPLANATION OF WEIGHTS," the decision maker explains why this is the most important difference.

4. In the next step, the decision maker must decide how important the remaining factor differences are relative to the most important difference, which was identified in the previous step. To do this, another factor difference in Figure 2.2 is selected and placed on the scale according to how important this factor difference is in relation to the most important difference. This judgment should be made by considering the actual differences between the factors for the two alternatives and the values of the factors themselves. For example, if employment is judged as the most important factor difference, and the difference in scenic beauty is only 40 percent as important as the employment difference, then the factor difference for "scenic beauty" would be placed opposite "40" on the scale. Also, the reasons for this judgment are stated in the explanation column.

Figure 2.2. Displaying Differences Between Two Alternatives

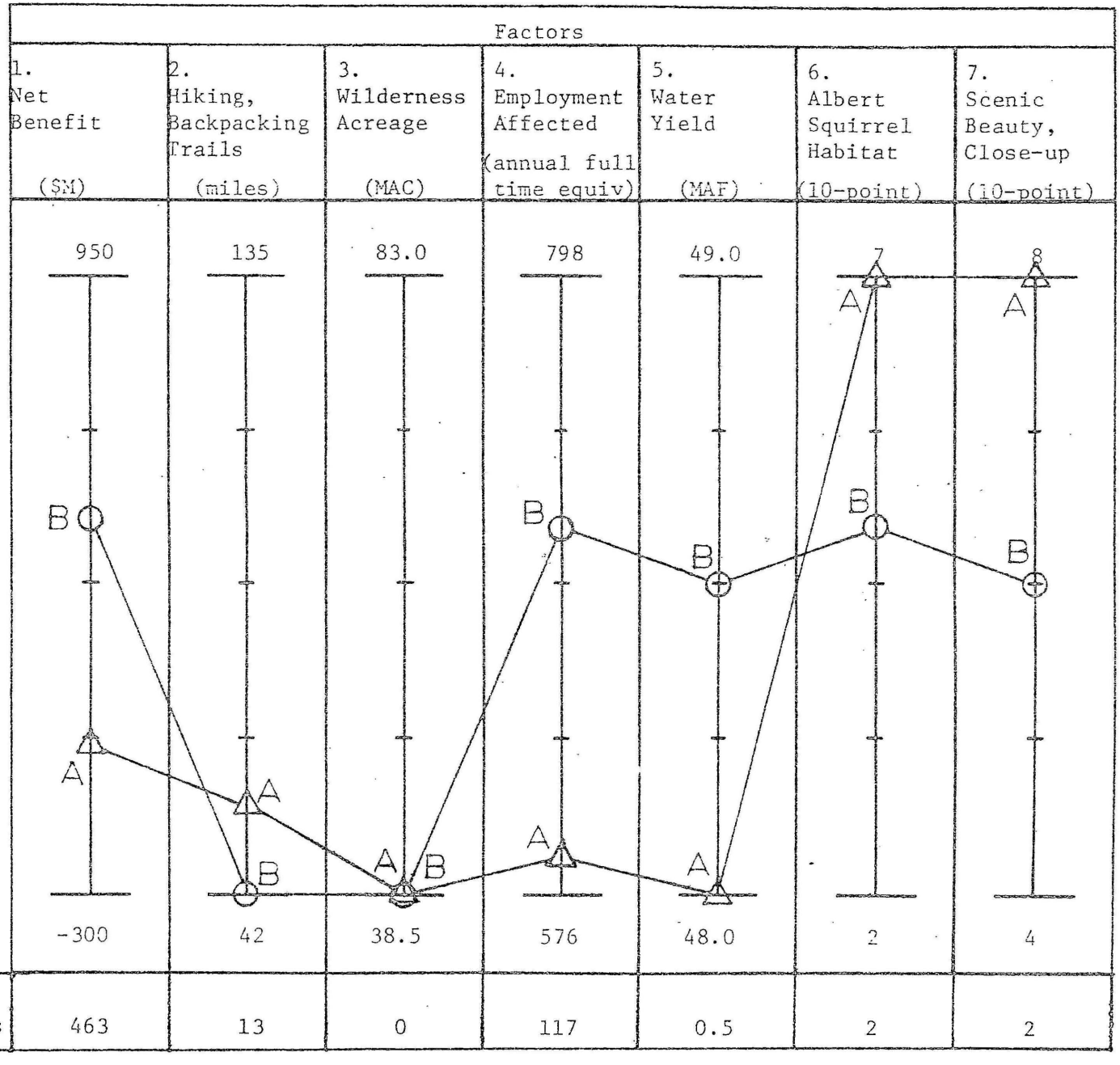


Figure 2.3. Scaling the Importance of Differences Between Alternatives

Name: Joe Ranger

Comparisons of Alternatives A and B

Scale	Factor Differences	Explanation of Weights
100	* Employment	The employment difference in by far the most important because of increased local income, added community stability and important positive social impacts that additional employment fosters
75		
50		
40	* Scenic Beauty	A decrease in scenic beauty would be unfortunate, especially in a forest with the potential of this one. However, the difference in employment levels is substantially more important
30	* Net Benefit	I estimate that the difference in net benefit is worth only 30% of the total social and economic good that would derive from the employment difference
25		
15	* Hiking/Backpacking	A loss of 13 miles of trails would only slightly complicate shortage problem.
10	* Water Yield	A 500 acre-feet difference in water supply is insignificant compared to an employment difference of 117 jobs.
5	* Squirrel Habitat	A substantial increase in employment is far more important than a slight decrease in Albert squirrel habitat
0	* Wilderness	There is no difference between the alternatives in wilderness area

5. After all factor differences have been placed on the scale, the final step is to check the completed scale to be sure that each factor difference is positioned in relation to all other differences according to the decision maker's actual preferences.

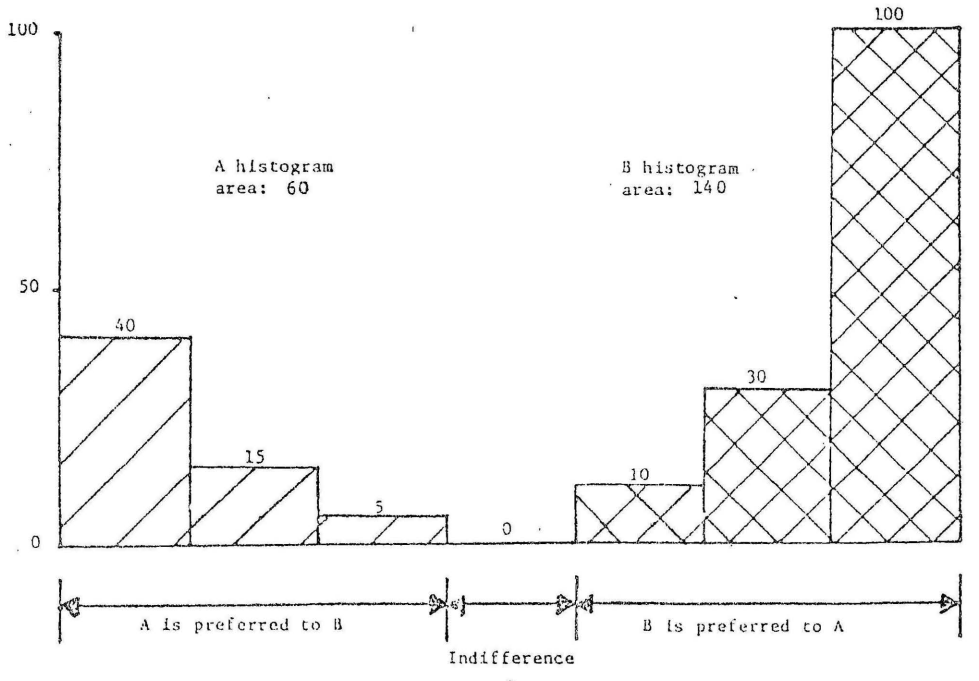
It should be noted that if the TEP process as described above is applied by a group rather than a single decision maker, a group concensus should be obtained at each step in the process. If this is not possible, minority opinions can be documented and reported.

2.4.4 Graphical Displays

A variety of graphical displays are possible for illustrating the results of a TEP analysis. One way to illustrate the judgments made about the trade-offs between two alternatives is the histogram-type of tradeoff display. The display illustrated in Figure 2.4 is constructed by going down the scale in Figure 2.3 and recording factor differences and their scaled importance values in the table in Figure 2.4. Going from top to bottom on the scale in Figure 2.3, if the first alternative is superior to the second for a given factor, then the factor difference and its scaled importance value are entered in the left-most column of the table. If the second alternative is superior for this factor, then the information is entered in the right-most column. As one goes down the scale in Figure 2.3, the columns in Figure 2.4 will gradually fill. When it is complete, the histogram can be drawn on the graph, as illustrated in Figure 2.4.

Figure 2.4. Histogram Type of Trade-off Display Comparing Alternatives A and B

	Factors						
	7 Scenic Beauty-Close-up Vantage (10-point scale)	2 Hiking/Backpacking (miles of trails)	6 Albert squirrel habitat (10-point scale)	3 Wilderness Acreage (1000 acres)	5 Water Yield to Metro City (1000 ac-ft)	1 Net Benefit ($1000)	4 Pineville employment affected (annual full time equiv.)
Differences	A > B 2	A > B 13	A > B 2	A = B 0	B > A 0.5	B > A 463	B > A 117
Scale Values	40	15	5	0	10	30	100



After the importance values have been plotted, the preferred alternative can be identified by examining the total histogram area for the two alternatives. The alternative with the largest histogram area is theoretically the preferred alternative. If the decision maker is not satisfied with the picture presented in the tradeoff display, he should go back, re-think the process, and correct the display to more accurately reflect his viewpoints. When the tradeoff display has been corrected, the process of comparing alternatives is continued using the preferred alternative of this comparison and another alternative that has not yet been examined. The final comparison of two alternatives identifies the preferred alternative.

3.0 AN EXAMPLE OF TEP IN NATIONAL FOREST LAND MANAGEMENT PLANNING

3.1 THE APPLICATION SETTING

The application of TEP discussed in this chapter was made on the Uinta National Forest, which is located in the Intermountain Region of the U.S. Forest Service. The application was made in connection with the identification of a preferred land management plan as required by the Resources Planning Act of 1975. The application involved several of the planners and all of the members of the ID Team, including the Forest Supervisor.

Due to the necessity of interfacing with the Uinta planning team's schedule and preceived information needs, it was not possible to adequately test any of the versions of TEP with members of the public, or to conduct a formal comparison of TEP with other techniques. However, the application that was conducted with the ID Team did establish TEP as a useful mechanism for identifying critical differences and trade-offs between alternatives and for documenting decision makers' viewpoints about them.

The materials that follow describe the manner in which TEP was applied by the Uinta National Forest planning team to identify a preferred alternative and to document the reasons behind

that decision.

3.2 IDENTIFICATION OF FACTORS

The Uinta planning team expended considerable effort in examining public issues and management concerns relative to deciding upon a land management plan for the forest. Ultimately, 14 factors were identified by the planning team to be used in comparing alternatives and evaluating trade-offs. These, and their units of measurement, are:

1. Grazing (1000's of animal unit months (AUM's) per year);
2. Developed Recreation (1000's of recreation visitor days (RVD's) per year);
3. Dispersed Recreation (1000's of RVD's per year);
4. Wildlife (1000's of RVD's per year);
5. Timber (1000's of board-feet of lumber produced annually);
6. Watershed (tons of sediment prevented from entering streams annually);
7. Firewood (cords produced per year);
8. Wilderness (1000's of acres);
9. Scenic Areas (1000's of acres);
10. Jobs (number of new jobs produced over the 50-year RPA planning horizon);
11. Visuals (change is total acres from current visual quality in "retention," "partial retention," and "preservation" categories);

12. Diversity (1000's of acres change from the diversity provided under current management activities);

13. ORV Use (1000's of RVD's change from current management); and

14. Present Net Worth (PNW) (millions of dollars accumulated value over the 50-year RPA planning horizon).

Data were not available for the ORV Use factor at the time the TEP analysis was conducted with the Uinta ID Team, and the factor was consequently not considered. As can be seen from the above list, the planning team judged all of the factors to be quantity-valued, and the last factor, PNW, is money-valued. In addition, as reported in the following section, a preliminary set of alternatives was considered in the TEP analysis wherein only grazing, developed recreation, dispersed recreation, wildlife, timber, watershed, firewood, wilderness, and present net worth were included. Data were not available on the other factors for this preliminary analysis of alternatives.

3.3 THE FIRST ITERATION: ANALYSIS OF PRELIMINARY ALTERNATIVES

3.3.1 Generation of Alternatives

The planning team generated an initial set of nine alternatives to be used as a starting point in addressing the issues and concerns surrounding land management on the Unita National Forest. The intent was to include in this initial set of alternatives a wide range of differences and trade-offs. The TEP process would then be used to explore these trade-offs and to

generate information useful in formulating newer and hopefully better alternatives. This process of formulating, examining, and re-formulating alternatives is viewed as an iterative one which very effectively assures that all issues and concerns are considered.

The initial nine alternatives, each emphasizing a different use of the national forest, were:

A. Current Management emphasis;

B. Developed and Dispersed Recreation emphasis;

C. Lumber Production emphasis;

D. Other Sillviculture emphasis;

E. Wilderness emphasis;

F. Livestock Production emphasis;

G. Terrestrial Wildlife emphasis;

H. Vegetative Conversion emphasis; and

I. Maximization of Net Present Worth.

Table 3.1 contains a summary of these alternatives in terms of the factors discussed in the previous section.

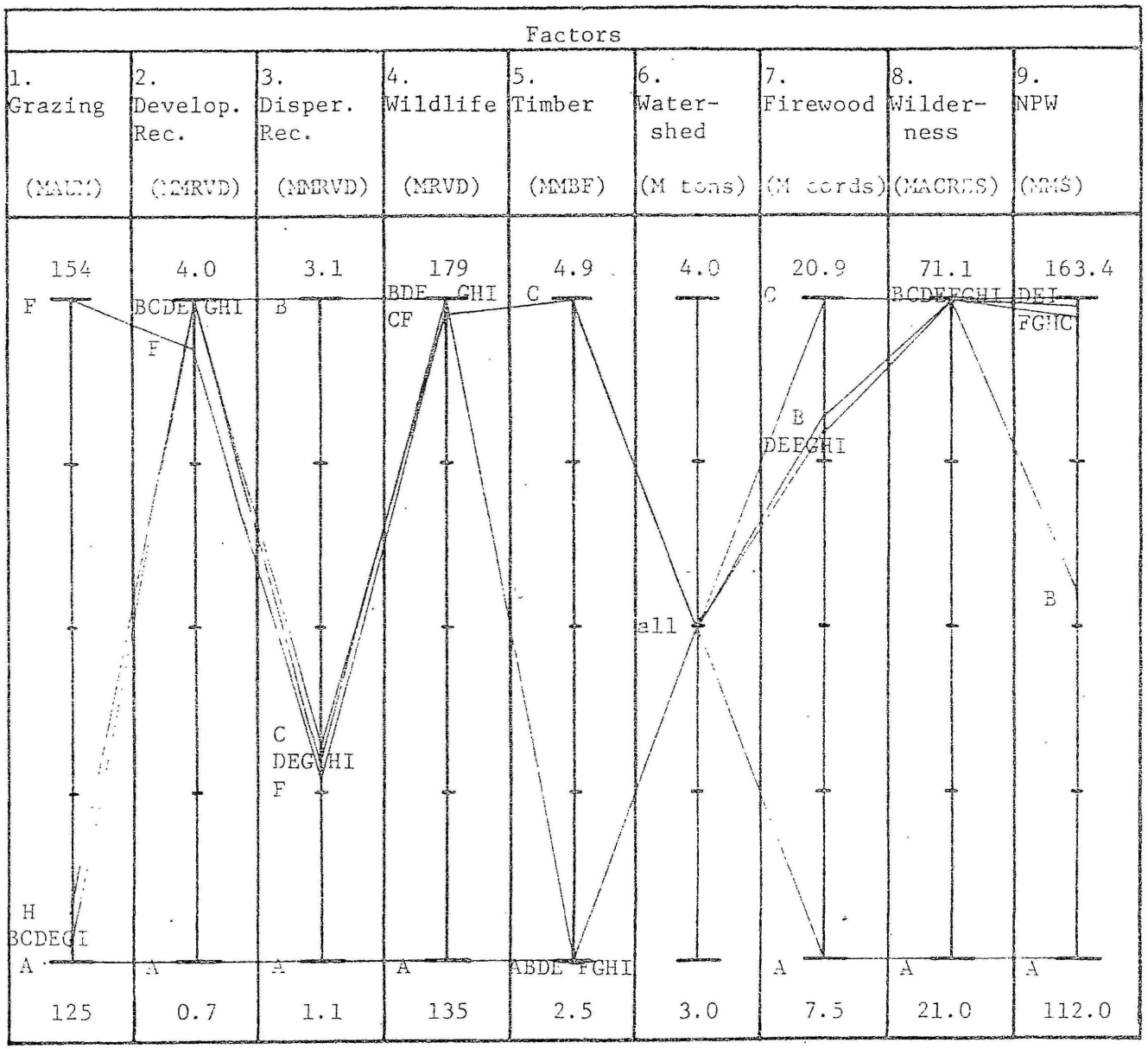
3.3.2 Comparison of Alternatives

Factor profiles were drawn for each of these nine alternatives. All nine profiles were overlayed in order to obtain a graphical summary of the range of trade-offs involved among the alternatives (see Figure 3.1). It can be readily seen that the

Table 3.1. Tabular Summary of Preliminary Uinta Alternatives

Alternative	Factors								
	1. Grazing (MAUM)	2. Develop. Rec. (MMRVD)	3. Disper. Rec. (MMRVD)	4. Wildlife (MRVD)	5. Timber (MMBF)	6. Water-shed (M tons)	7. Firewood (M cord)	8. Wilder-ness (MACRES)	9. NPW (MM$)
A	125	0.7	1.1	135	2.5	3.5	7.5	21.0	112.0
B	126	4.0	3.1	179	2.5	3.5	18.5	71.1	141.0
C	126	4.0	1.6	178	4.9	3.5	20.9	71.1	162.0
D	126	4.0	1.6	179	2.5	3.5	18.5	71.1	163.4
E	126	4.0	1.6	179	2.5	3.5	18.5	71.1	163.4
F	154	3.8	1.6	178	2.5	3.5	18.5	71.1	160.0
G	126	4.0	1.6	179	2.5	3.5	18.5	71.1	163.1
H	127	4.0	1.6	179	2.5	3.5	18.5	71.1	162.9
I	126	4.0	1.6	179	2.5	3.5	18.5	71.1	163.4

Figure 3.1. Composite Factor Profiles for Preliminary Uinta Alternatives



Current Management alternative was dominated. Moreover, within the margin of error of the techniques used to predict the measurements of the various factors, the alternatives involving Other Sillviculture, Wilderness, Terrestrial Wildlife, Vegetative Conversion, and Maximum NPW were also dominated. Of the original nine alternatives, then, only three had potentially significant differences, and these only for the factors of Grazing, Dispersed Recreation, Timber, and Firewood. At this point, the planning team decided to generate some new alternatives which would provide a better representation of the potential range of differences among the various factors considered on the Uinta. This process of generating alternatives, examining differences, and re-generating alternatives was continued by the planning team until a final set of 13 alternatives was obtained. In the judgment of the planning team, this set contained sufficient differences among the alternatives to adequately address the issues and management concerns.

3.4 THE FINAL ITERATION: ANALYSIS OF FINAL ALTERNATIVES

3.4.1 Generation of New Alternatives

The procedures described above led to the following set of alternatives, one of which would be selected as the preferred alternative:

A. No action (continue current management);

B. Maximize cost effectiveness with minimum criteria constraining the various resources;

C. Optimize the RPA goals disaggregated through the Interim Regional Plan to the Forest; the only constraint applied was that which established upper limits less than the RPA targets where legal mandates, resource suitability, and unreasonable opportunity costs would not justify meeting those RPA targets;

D. Maximize public preference;

E. Emphasize meeting public preference with cost effectiveness considered;

F. Emphasize cost effectiveness with timber and watershed adjusted to reflect local public preference;

G. Emphasize cost effectiveness with an adjustment of timber to levels preferred by the local public;

H. Emphasize management of roadless areas as classified wilderness;

I. Emhpasize restriction of classified wilderness for the roadless areas;

J. Emphasize cost effectiveness with wildlife and timber adjusted to reflect local public preferences;

K. Emphasize cost effectiveness with timber adjusted to reflect local public preference and watershed maximized;

L. Emphasize cost effectiveness with timber and watershed adjusted to reflect local public preference with dispersed recreation constrained to the RPA level; and

M. Emphasize cost effectiveness with timber adjusted to reflect local public preference while also maximizing watershed benefits and constraining dispersed recreation at the RPA level.

Table 3.2 presents a summary of these alternatives in terms of the factors discussed in Section 3.2.

Table 3.2. Tabular Summary of Final Uinta Alternatives

Alternatives	Factors												
	1. Grazing (MAUM)	2. Dev. Rec. (MRVD)	3. Disp. Rec. (MRVD)	4. Wildlife (MRVD)	5. Timber (MMBF)	6. Watershed (sed.red., M-tons)	7. Firewood (M-cords)	8. Wilder-ness (MACRES)	9. Scenic Areas (MACRES)	10. Jobs (50-year total)	11. Visuals	12. Diver-sity MACRES	13. PNW (MMS)
A. Current	125	0.7	1.1	135	2.5	3.5	8	21	10.8	0	0.0	1.5	114
B. Max. Cost Effect. w/min. Criteria	131	1.7	1.6	178	1.9	3.5	18	21	60.9	810	10.0	9.4	151
C. RPA	154	1.7	2.2	177	4.9	11.0	21	21	60.9	1350	0.0	18.8	138
D. Public Max. Preference	127	1.7	1.1	153	3.0	11.5	20	21	60.9	1270	2.1	10.6	129
E. Public w/ cost Effect. Considered	131	1.7	1.6	164	1.9	7.0	18	21	60.9	790	7.7	11.4	149
F. Cost Effect. w/ Adjusted timber & water	131	1.7	1.6	178	1.9	7.0	18	21	60.9	810	7.7	12.4	150
G. Cost Effect. w/ Adjusted Timber	131	1.7	1.6	178	1.9	3.5	18	21	60.9	810	7.7	12.4	151
H. K plus Wilderness	131	1.7	1.6	178	1.9	11.5	18	71	10.8	810	8.5	13.2	147
I. K plus no wilder-ness or Scenic.	131	1.7	1.6	178	1.9	11.5	18	21	10.8	810	4.5	13.2	149
J. Cost Effect. w/adj. Wilderness & Timber	131	1.7	1.6	164	1.9	3.5	18	21	60.9	790	7.6	11.4	150
K. 6-F plus Max. Water	131	1.7	1.6	178	1.9	11.5	18	21	60.9	810	8.5	13.2	149
L. 6-F plus RPA Disp.	131	1.7	2.2	178	1.9	7.0	18	21	60.9	1320	7.7	12.4	140
M. 6-F plus Max.Water & RPA Disp.	131	1.7	2.2	178	1.9	11.5	18	21	60.9	1320	8.5	13.2	140

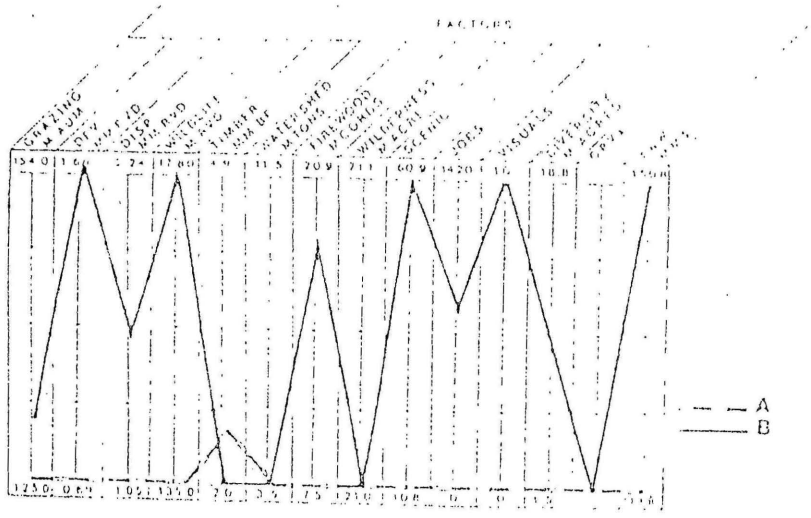
3.4.2 Detailed TEP Analysis

Following the steps illustrated in Section 2.4, the Uinta planners and ID Team applied TEP to compare the above alternatives, to evaluate trade-offs among them, and to identify one of them as the preferred alternative. Figures 3.2 through 3.13 present the results of the paired comparison tests conducted by the ID Team. For each paired comparison, the differences between the two alternatives are clearly identified, the advantages of each alternative are clearly stated, and the basis for selecting one alternative over the other is given. Finally, a histogram is provided as a graphical summary of the decision makers' viewpoints about the relative importance of the various advantages (factor differences) of each alternative.

3.4.3 The Decision

As can be seen in the pairwise comparisons of Figures 3.2 through 3.13, the alternative that emerges as the preferred selection is Alternative K, the cost effectiveness emphasis with adjustments in timber production and watershed sedimentation. In the viewpoint of the members of the ID Team, the advantages found in Alternative C for jobs, diversity, and firewood were not sufficient to offset the advantages of Alternative K for the remaining factors. Of special importance in comparing these two alternatives was the 11.9 million dollar factor difference in NPW, which was an advantage to Alternative K.

Figure 3.2. Pairwise Comparison of Alternatives A and B



A Advantages

0.5 MMBF Timber

B Advantages

37 MM$ Present Net Worth
985 MRVD Developed Recreation
43 MRVD Wildlife
546 MRVD Dispersed Recreation
40.1 MACRES Scenic Area
810 Jobs
1,050 CORDS Firewood
10 Visuals Equivalents
5.5 MAUM Livestock Grazing
8.0 MACRES Habitat Diversity

Alternative B is significantly closer to the preferred public levels than A and has a very large advantage in PNW.

Select B over A.

FACTOR	ADVANTAGE
Timber	0.5
Watershed	0.0
Wilderness	0.0
ORV	0.0
Diversity	8.0
Grazing	5.5
Visuals	10.0
Firewood	1,050.0
Jobs	810.0
Scenic Area	50.1
Disp. Rec.	596.0
Wildlife	43.0
Dev. Rec.	985.0
PNW	37.0

ADVANTAGE WEIGHTS

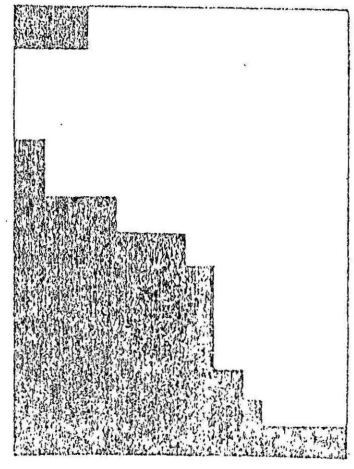
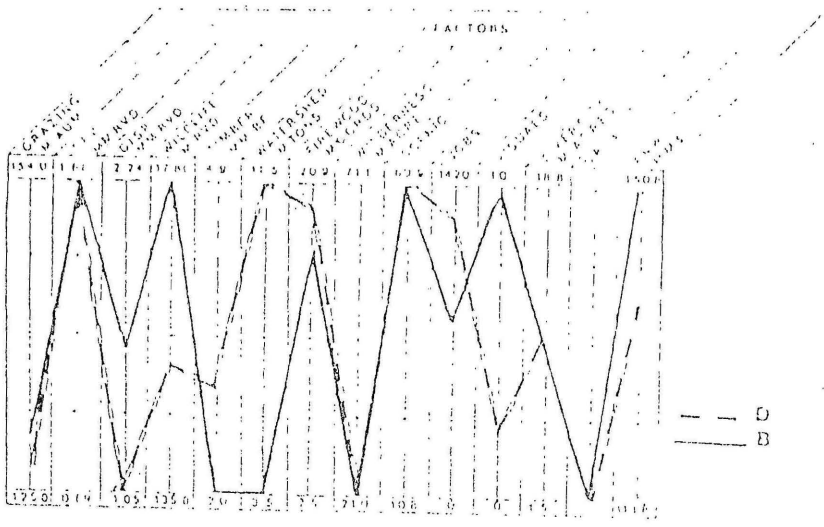


Figure 3.3. Pairwise Comparison of Alternatives B and D



B Advantages	D Advantages
21.9 MM$ PNW	8.0 MTONS Sediment Reduction
546 MRVD Dispersed Recreation	1.0 MMBF Timber
25 MRVD Wildlife	460 Jobs
7.9 Visual Equivalents	2000 CORDS Firewood
2.5 MAUM Livestock Grazing	1.2 MACRES Habitat Diversity

The increased water quality in D is preferable to the public; however, there is a very large difference in PNW with only minor advantage in jobs, timber, firewood, and diversity.

The water quality is not equal to the gains in wildlife, visuals, dispersed recreation, and PNW.

Select B over D.

FACTOR	ADVANTAGE
Watershed	8.0
Timber	1.0
Jobs	460.0
Firewood	2,000.0
Diversity	1.2
Dev. Rec.	0.0
Wilderness	0.0
Scenic Areas	0.0
ORV	0.0
Grazing	2.5
Visuals	7.9
Wildlife	25.0
Disp. Rec.	546.0
PNW	21.9

ADVANTAGE WEIGHTS

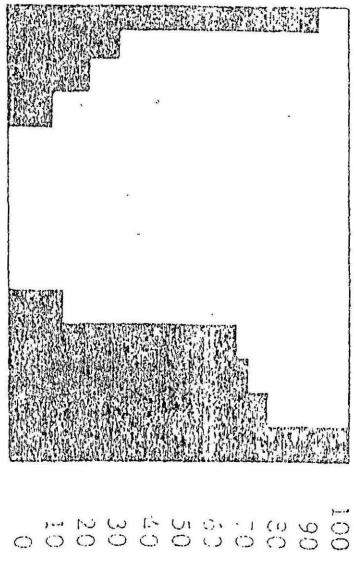
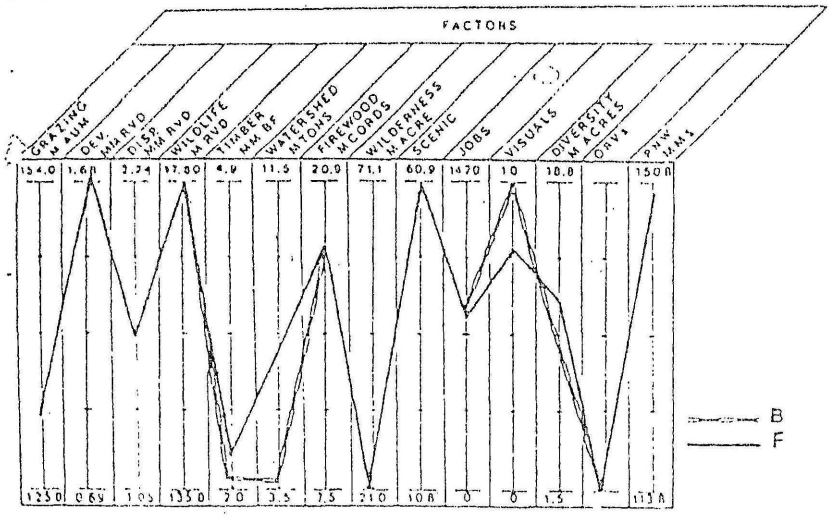


Figure 3.4. Pairwise Comparison of Alternatives B and F



F Advantages	B Advantages
3.5 M Ton Sediment Reduction	2.3 Visual Equivalents
3 MACRES Habitat Diversity	0.8 MM$ PNW
0.2 MMBF Timber	

Watershed is an important issue and the cost in PNW is minor to achieve this increase in water quality.

The sacrifice in PNW and visuals to move timber harvest to a level that would apparently be acceptable to the public is minor.

Select F over B.

FACTOR	ADVANTAGE
Visuals	2.3
NPW	0.8
Grazing	0.0
Dev. Rec.	0.0
Wildlife	0.0
Firewood	0.0
Wilderness	0.0
Scenic Areas	0.0
Jobs	0.0
ORV	0.0
Disp. Rec.	3.0
Timber	0.2
Diversity	3.0
Watershed	3.5

ADVANTAGE WEIGHTS

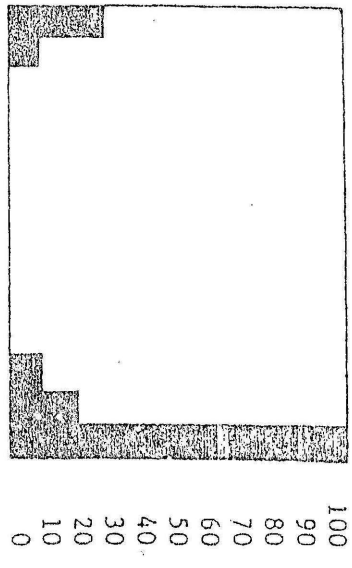
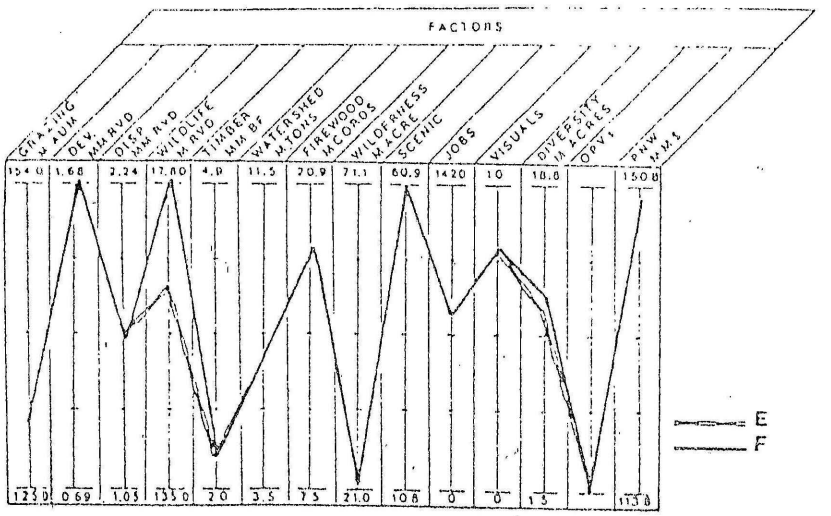


Figure 3.5. Pairwise Comparison of Alternatives F and E



F Advantages

14 MRVD Wildlife
20 Jobs
1 MACRE Habitat Diversity
0.8 MM$ PNW

E Advantages

None

Select F since E has no advantages.

FACTOR	ADVANTAGE
Grazing	0.0
Dev. Rec.	0.0
Disp. Rec.	0.0
Timber	0.0
Watershed	0.0
Firewood	0.0
Wilderness	0.0
Scenic	0.0
Visuals	0.0
ORV	0.0
PNW	0.8
Diversity	1.0
Jobs	20.0
Wildlife	14.0

ADVANTAGE WEIGHTS

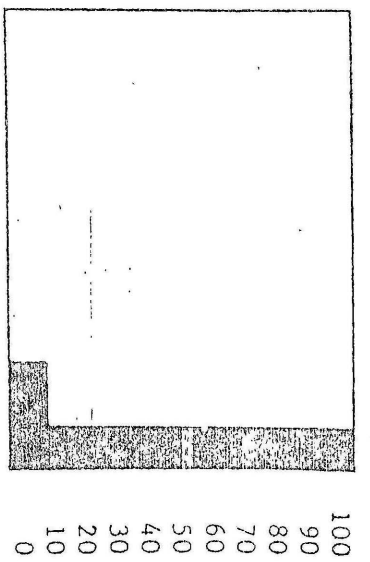
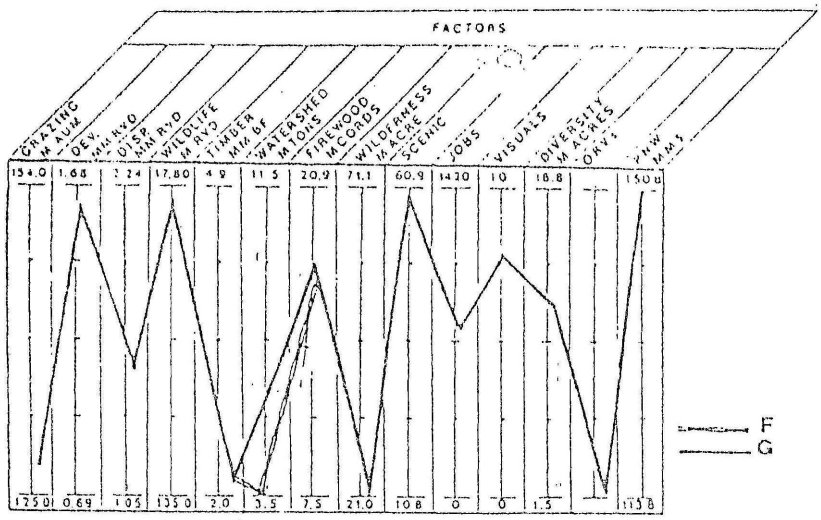


Figure 3.6. Pairwise Comparison of Alternatives F and G



F Advantages	G Advantages
3.5 MTONS Sediment Reduction	0.6 MM$ PNW

The increased water quality is significant in the resolution of public issues and the required PNW tradeoff is small.

Select F over G.

FACTOR	ADVANTAGE
PNW	0.6
Grazing	0.0
Dev. Rec.	0.0
Disp. Rec.	0.0
Wildlife	0.0
Timber	0.0
Firewood	0.0
Wilderness	0.0
Scenic Area	0.0
Jobs	0.0
Visuals	0.0
Diversity	0.0
ORV	0.0
Watershed	3.5

ADVANTAGE WEIGHTS

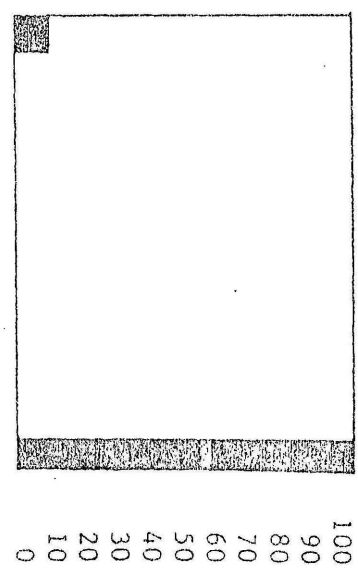
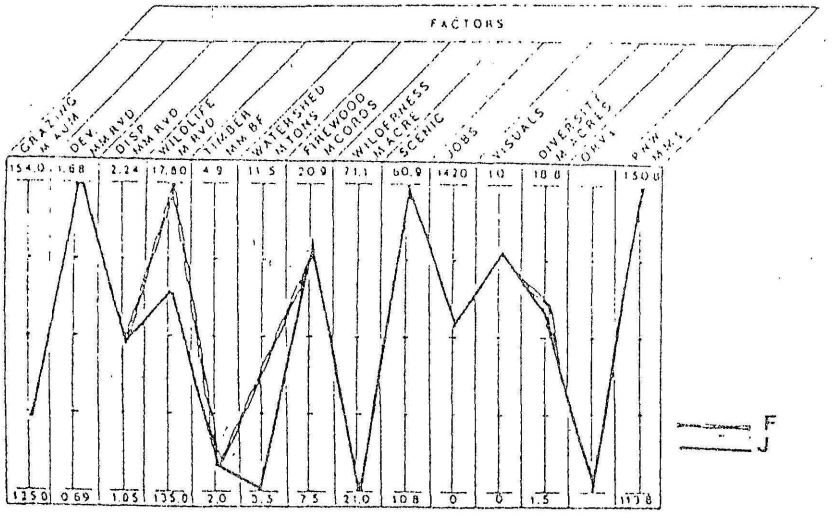


Figure 3.7. Pairwise Comparison of Alternatives F and J



F Advantages	J Advantages
3.5 MTONS Sediment Reduction	None
14 MRVD Wildlife	
20 Jobs	
0.2 MM$ PNW	
0.1 Visual Equivalents	
1.0 Habitat Diversity	

Select F, since J has no advantages.

FACTOR	ADVANTAGE
ORV	0.0
Grazing	0.0
Dev. Rec.	0.0
Disp. Rec.	0.0
Timber	0.0
Firewood	0.0
Wilderness	0.0
Scenic Areas	0.0
Visuals	0.1
PNW	0.2
Diversity	1.0
Jobs	20.0
Wildlife	14.0
Watershed	3.5

ADVANTAGE WEIGHTS

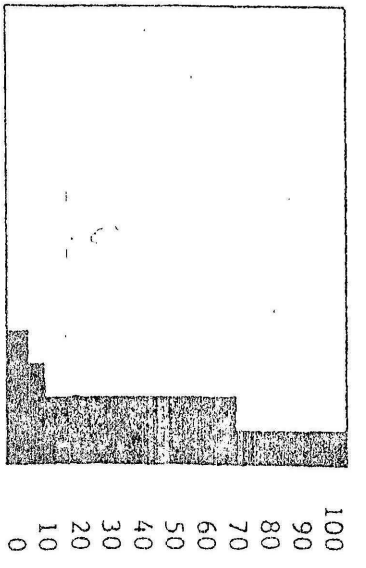
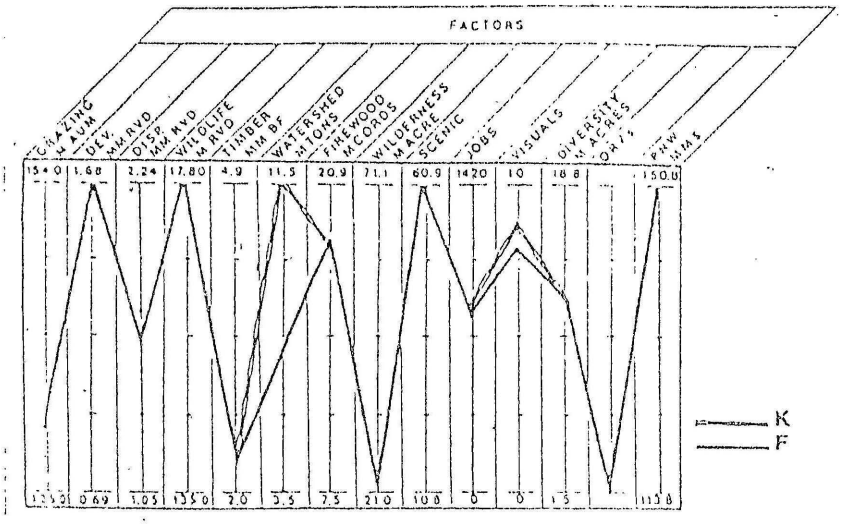


Figure 3.8. Pairwise Comparison of Alternatives K and F



F Advantages	K Advantages
0.6 MM$ PNU	4.8 MTONS Sediment Reduction
	0.8 Visual Equivalents
	0.8 MACRES Diversity

The K advantage in improved water quality is more significant in resolving issues than the PNW cost.

Select K over F.

FACTOR	ADVANTAGE
PNW	0.6
Dev. Rec.	0.0
Dispersed Rec.	0.0
Wildlife	0.0
Timber	0.0
Firewood	0.0
Wilderness	0.0
Scenic Areas	0.0
Jobs	0.0
ORV	0.0
Grazing	0.0
Diversity	0.8
Visuals	0.8
Watershed	4.8

ADVANTAGE WEIGHTS

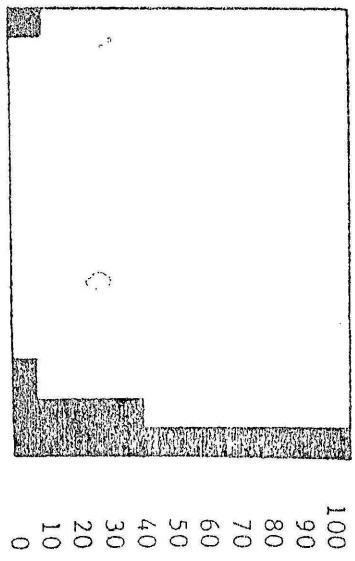
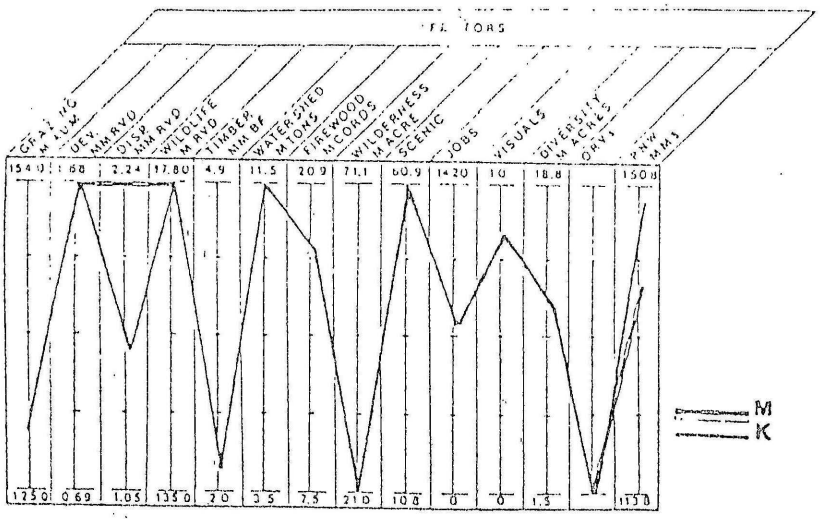


Figure 3.9. Pairwise Comparison of Alternatives K and M



K Advantages

10.3 MM PNW

M Advantages

641 MRVD Dispersed Recreation

The PNW cost is $200,000 per year to obtain an increase of 90,000 RVD per year. Both factors are significant; however, dispersed recreation in the K alternative has an increase of 550 MRVD over current. Do not select an additional increase in Dispersed Recreation.

Select K over M.

FACTOR	ADVANTAGE
Disp. Rec.	641.0
Grazing	0.0
Dev. Rec.	0.0
ORV	0.0
Wildlife	0.0
Timber	0.0
Watershed	0.0
Firewood	0.0
Wilderness	0.0
Scenic Area	0.0
Jobs	0.0
Visuals	0.0
Diversity	0.0
PNW	10.3

ADVANTAGE WEIGHTS

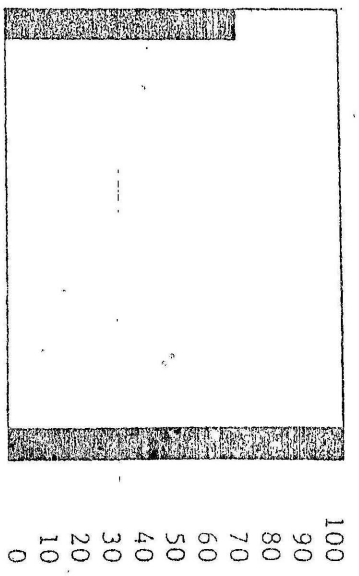
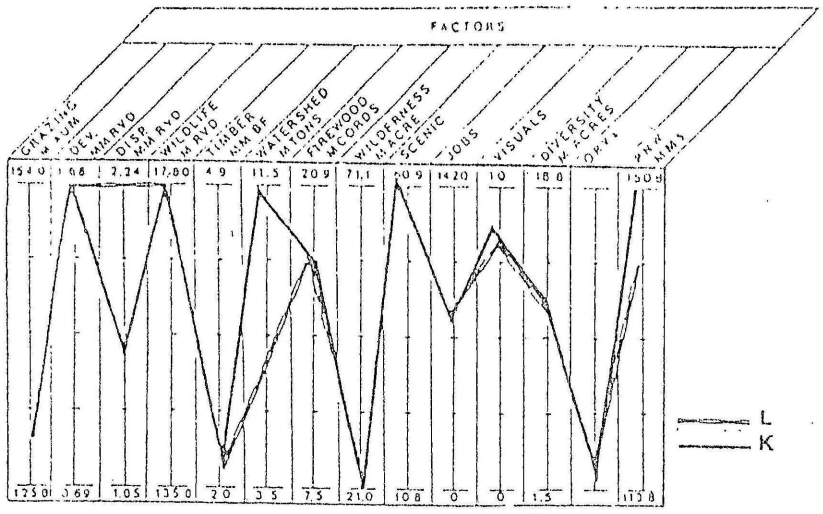


Figure 3.10. Pairwise Comparison of Alternatives K and L



K Advantages

9.0 MM$ PNW
4.5 MTONS Sediment Reduction
0.8 Visual Equivalents
0.8 MACRES Habitat Diversity

L Advantages

641 MRVD Dispersed Recreation

K has an increase of 550 MRVD over current. Do not select additional RVD, at so significant a PNW cost. The sediment reduction is also a significant advantage of K.

Select K over L.

FACTOR	ADVANTAGE
Dispersed Rec.	641.0
Grazing	0.0
Dev. Rec.	0.0
Wildlife	0.0
Timber	0.0
Firewood	0.0
Wilderness	0.0
Scenic Area	0.0
Jobs	0.0
ORV	0.0
Diversity	0.8
Visuals	0.8
Watershed	4.5
PNW	9.0

ADVANTAGE WEIGHTS

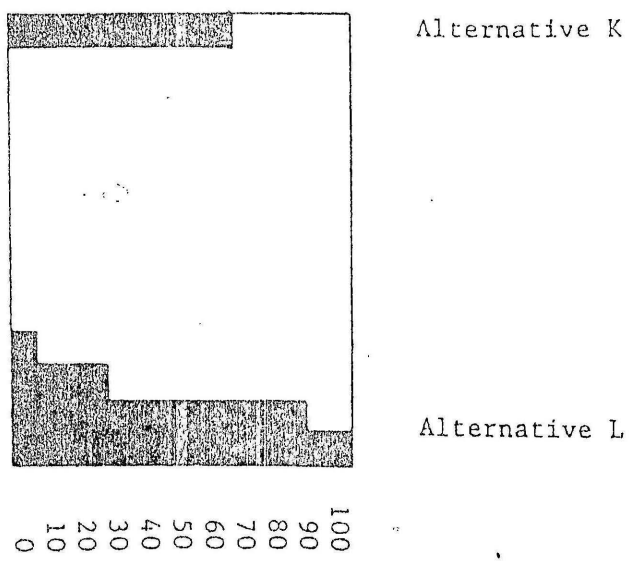
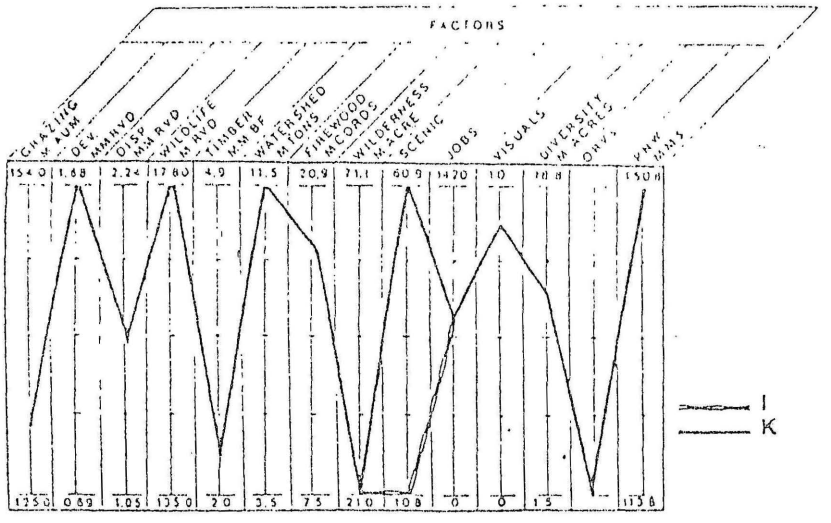


Figure 3.11. Pairwise Comparison of Alternatives K and I



K Advantages	I Advantages
50.1 MACRES Scenic Area	None
4.0 Visual Equivalents	

Select K since I has no advantages.

FACTOR	ADVANTAGE
PNW	0.0
Dev. Rec.	0.0
Disp. Rec.	0.0
Wildlife	0.0
Timber	0.0
Watershed	0.0
Firewood	0.0
Wilderness	0.0
Jobs	0.0
Diversity	0.0
ORV	0.0
Grazing	0.0
Visuals	4.0
Scenic Areas	50.1

ADVANTAGE WEIGHTS

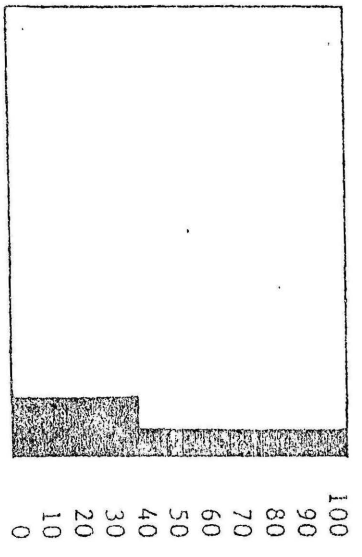
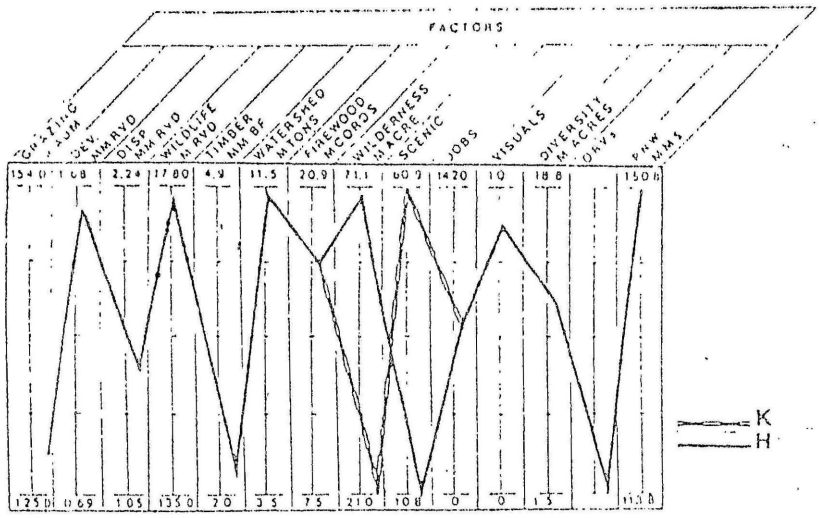


Figure 3.12. Pairwise Comparison of Alternatives K and H



K Advantages	H Advantages
50.1 MACRES Scenic Area	50.1 MACRES Wilderness

It appears that the majority of the public would prefer the areas not to be designated Wilderness yet remain unroaded. A scenic area designation allows us to meet these objectives and retain more flexibility in writing a management prescription than wilderness designation. Alternative K is more responsive to state and local governmental concerns than H.

Select K over H.

FACTOR	ADVANTAGE
Wilderness	50.1
Grazing	0.0
Dev. Rec.	0.0
Disp. Rec.	0.0
Wildlife	0.0
Timber	0.0
Watershed	0.0
Firewood	0.0
Jobs	0.0
Visuals	0.0
Diversity	0.0
ORV	0.0
PNW	0.0
Scenic Areas	50.1

ADVANTAGE WEIGHTS

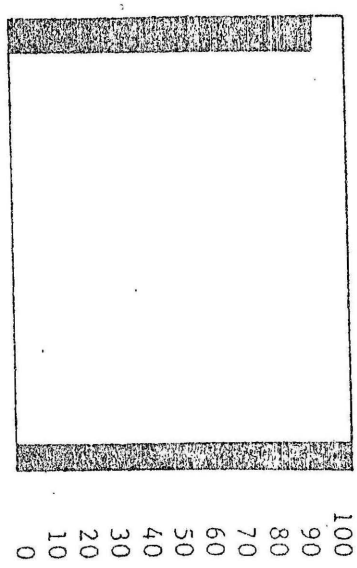
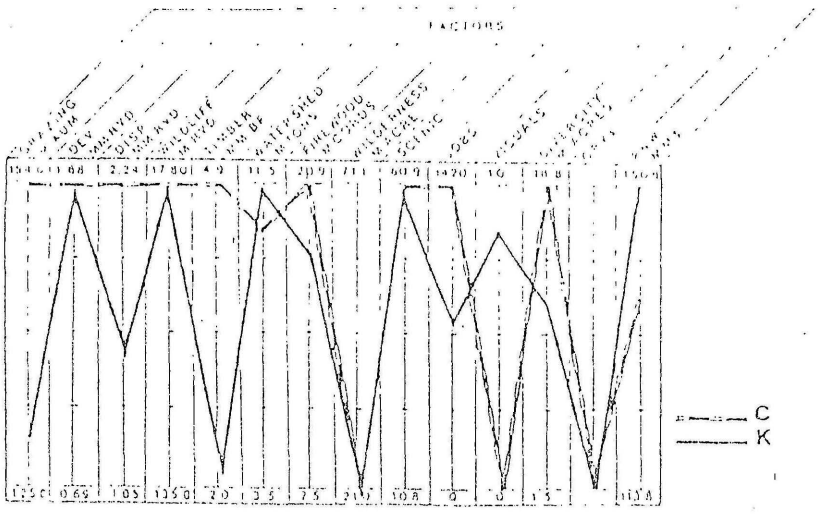


Figure 3.13. Pairwise Comparison of Alternatives K and C



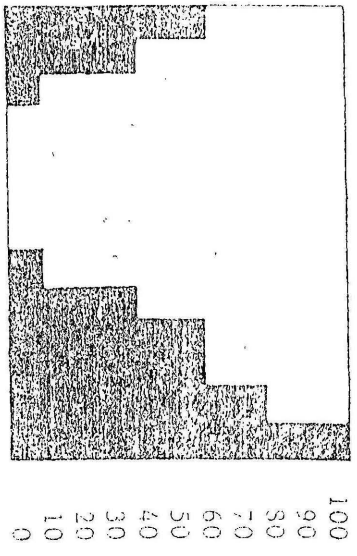
K Advantages	C Advantages
11.9 MM$ PNW	540.0 Jobs
8.5 Visual Equivalents	5.6 MACRES Habitat Diversity
24 MAUM Livestock Grazing	3 MCORDS Firewood
641 MRVD Dispersed Recreation	
2.7 MMBF Sawtimber	
0.5 MTONS Sediment Reduction	

The PNW cost is not offset by the advantages of C.

Select K over C.

FACTOR	ADVANTAGE
Jobs	540.0
Diversity	5.6
Firewood	3.0
Dev. Rec.	0.0
Wildlife	0.0
Wilderness	0.0
Scenic	0.0
ORV	0.0
Watershed	0.5
Timber	2.7
Disp. Rec.	641.0
Grazing	24.0
Visuals	8.5
PNW	11.9

ADVANTAGE WEIGHTS



4.0 SUMMARY AND RECOMMENDATIONS

4.1 SUMMARY

The work discussed in this report is the result of research conducted in the design and testing of an information management and communication device called TEP, which is intended for use as a decision aid in complex natural resources management problems. The principal philosophy behind TEP is the belief that decisions about public resources should be based on the viewpoints that decision makers have about trade-offs between alternatives, and that these viewpoints should be documented and displayed.

Though various versions of TEP were formulated by the project, only the simplest and most theoretically acceptable version was tested on the Uinta National Forest. This version, involving paired comparisons of discrete alternatives, proved to be an efficient means of identifying differences and trade-offs, and eliciting and documenting viewpoints about them. The time involved in conducting 12 paired comparisons was not at all excessive, and the process of involving the entire ID Team in comparing alternatives and assessing trade-offs was very efficient in obtaining a variety of viewpoints from a range of disciplines. Integrating these viewpoints into a single decision was not difficult for the members of the decision team, who were ac-

customed to working together. Finally, although it was not possible to systematically compare TEP against other methodologies, the general concensus of the members of the planning and decision teams was that TEP is superior to other approaches with which they had had experience.

4.2 RECOMMENDATIONS

Many things about TEP remain to be tested or improved. First, in any pairwise comparison approach there is the possible occurance of intransitivity of preferences among alternatives. The manner in which TEP was applied on the Uinta National Forest did not allow for testing for intransitivities. More theoretical work needs to be done with regard to the pairwise comparison approach of TEP and the likelihood of intransitivities as well as the interpretation of their meaning and estimation of their causes.

Second, improvements need to be made in the display mechanisms used in TEP to facilitate the display of the basis of a decision or the outcome of a comparison of two alternatives. Graphical techniques need to be created which can be used to improve upon or augment the histograms which display viewpoints about differences and tradeoffs.

Third, other versions of TEP need to be more thoroughly tested on the public to determine their effectiveness in generating public viewpoint and opinion data for use in the decision making process. Such a test was not possible during the project.

Finally, measures for more efficiently capturing and recording viewpoints about trade-offs need to be more systematically incorporated in TEP. When TEP is used by a large group of decision makers, ideas, viewpoints, and opinions frequently are expressed too quickly to be accurately recorded by hand. Also, the reporting of these viewpoints is sometimes terse or inadequate (see Figures 3.2 through 3.13), even if they were adequately recorded in the TEP analysis. Therefore, users of TEP should be cautioned to make full use of the documentation of viewpoints which results from a TEP application, for it is this rationale that TEP is intended to make visible.

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